

(19)



Europäisches Patentamt

European Patent Office

Office européen des brevets



(11)

EP 1 363 460 A2

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
19.11.2003 Bulletin 2003/47

(51) Int Cl.7: H04N 9/31

(21) Application number: 03252873.9

(22) Date of filing: 08.05.2003

(84) Designated Contracting States:

AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HU IE IT LI LU MC NL PT RO SE SI SK TR

Designated Extension States:

AL LT LV MK

(72) Inventors:

- Sakata, Hidefumi, c/o Seiko Epson Corporation Suwa-shi, Nagano-ken 392-8502 (JP)
- Takeda, Takashi, c/o Seiko Epson Corporation Suwa-shi, Nagano-ken 392-8502 (JP)

(30) Priority: 10.05.2002 JP 2002135641

(74) Representative: Sturt, Clifford Mark et al
Miller Sturt Kenyon
9 John Street
London WC1N 2ES (GB)

(71) Applicant: SEIKO EPSON CORPORATION
Shinjuku-ku, Tokyo 163-0811 (JP)

(54) Lighting system and projector

(57) The invention seeks to provide a compact, thin, and lightweight lighting system and projector. A lighting system included in a projector 1 according to the present invention is provided with an LED array 2 having LEDs

14R, 14G, and 14B and a reflective plate 15 at the rear side of the LEDs in the light emitting direction, retardation films 3, a taper rod lens array 4, a rod lens array 7, and a reflective polarizing plate 8.

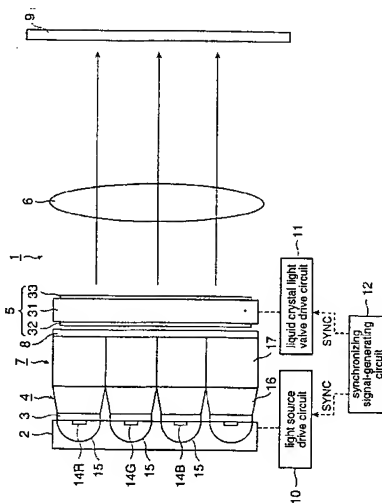


FIG. 1

Description

[0001] The present invention relates to a lighting system and a projector and particularly to a structure of a lighting system having a high efficiency for light utilization.

[0002] A projector is known that combines imaging light with a light modulation unit such as a liquid crystal light valve and projects the combined and enlarged light image on a screen from a projection optical system comprising a projection lens. In a lighting optical system used in such a projector, light emerging from a light source such as a metal halide lamp is randomly polarized light. However, a liquid crystal projector including a liquid crystal light valve using polarized light utilizes only polarized light in one direction for displaying. When light from the light source is incident on the liquid crystal light valve, nearly a half quantity of light is absorbed in a polarizing plate at the light incident side, the absorbed light being not utilized for displaying.

[0003] In order to improve the efficiency for light utilization, a conventional liquid crystal projector is provided with polarization conversion means between the light source and the liquid crystal light valve for converting randomly polarized light from the light source to unidirectionally polarized light that is used for displaying. A polarization conversion means generally used is a polarized beam splitter (PBS) array. The PBS array is a combination of a plurality of PBSs, each having a polarization beam separation film and a reflective film, and a retardation film such as a $1/2$ wavelength film. The PBS array has a function that one of the p-polarized light component and the s-polarized light component contained in the light from the light source is converted to the other.

[0004] Unfortunately, the polarization conversion means having the PBS array of the conventional projector has the following problems.

[0005] Since each PBS element has a measure of area, the PBS array including PBS elements inevitably has a considerable size and does not meet the recent requirements of reduction in the size, thickness, and weight of the projector. Furthermore, the light must be incident on the polarization beam separation films of the PBS array. Thus, a lens system is required to converge the light to the polarization beam separation films. Accordingly, the structure of the polarization conversion means is complicated. In addition, the p-polarized light and the s-polarized light separated by the polarization beam separation film have different optical path lengths, resulting in shifting of the lighting condition on the light valve and thus a decrease in efficiency for light utilization.

[0006] For solving the above problems, an object of the present invention is to provide a compact, thin, and lightweight lighting system having a high efficiency for light utilization and a simple structure, and to provide a compact, thin, and lightweight liquid crystal projector

provided with the lighting system.

[0007] For achieving the above object, a lighting system according to the present invention comprises at least one light source, polarization conversion means that polarizes light from the light source in one direction, and at least one reflection plate that is disposed at the rear side of the light source in the light emitting direction such that the reflective face of the reflection plate is opposite to the light source, wherein the polarization conversion means is provided at the light emitting side of the light source, the polarization conversion means having a reflective polarizing plate that transmits polarized light having a predetermined vibration direction and reflects polarized light having vibration directions other than the predetermined vibration direction.

[0008] According to this structure, the reflective polarizing plate that transmits one type of polarized light (for example, p-polarized light) and reflects the other type of polarized light (for example, s-polarized light) is provided at the light emitting side of the light source. When randomly polarized light from the light source is incident on the reflective polarizing plate, for example, the p-polarized light passes through the reflective polarizing plate while the s-polarized light is reflected toward the light source. The reflected light toward the light source is re-reflected by the reflection plate provided at the rear of the light source toward the reflective polarizing plate. If the light that did not pass through the reflective polarizing plate repeatedly travels between the reflective polarizing plate and the reflection plate as long as the polarization state of the light does not vary. In fact, the polarization state of the reflected light gradually varies during the repeated reflection. Thus, part of the reflected light passes through the reflective polarizing plate, and the unabsorbed light finally passes through the reflective polarizing plate. When the lighting system of the present invention is applied to a projector, the light that is first reflected by the reflective polarizing plate finally passes through the reflective polarizing plate toward light modulation means if the polarization of the light is oriented to a predetermined direction. The lighting system of the present invention thus has a higher efficiency for light utilization than conventional systems.

[0009] In the lighting system of the present invention, the reflective polarizing plate is used as an element having a polarization conversion function, in place of a conventional PBS array. The reflective polarizing plate may be, for example, a multilayer polarizing film, which contributes to achievement of a compact, thin, and lightweight display, unlike the PBS array. The reflective polarizing plate can receive light on the entire surface, and does not require convergence of light to a specific position that is essential for the PBS array. Thus, the polarization conversion optical system needs no optical lens, resulting in a simplified structure. Furthermore, a wavelength plate, which is essential for the PBS array, is not required; hence, the number of the component can be reduced.

[0010] The lighting system according to the present invention preferably further comprises a retardation film between the light source and the reflective polarizing plate.

[0011] According to this structure, in addition to a spontaneous change in polarization when the light is reflected by the reflective polarizing plate or the reflection plate, in this structure, the retardation film actively changes the polarization state; hence, the change in the polarization is enhanced when the light reciprocally travels between the reflective polarizing plate and the reflection plate. As a result, the light transmittance of the reflective polarizing plate increases so that the efficiency for light utilization can be improved. Preferably, the retardation film has various phase differences at positions transmitting the light, rather than a uniform phase difference such as a half-wave or quarter-wave phase difference. According to this structure the light reciprocally traveling between the reflective plate and the reflective polarizing plate is subjected to different types of phase modulation in the forward path and the backward path, resulting in an enhanced change in the polarization state.

[0012] The lighting system preferably further comprises a rod light guide or a tubular light guide between the light source and the reflective polarizing plate, the tubular light guide having a reflective inner face. Herein, "the rod light guide" or "the tubular light guide having a reflective inner face" indicates a conventional rod lens.

[0013] According to this structure, the light guide (rod lens) not only introduces the light emerging from the light source to the reflective polarizing plate and but also reflects the light at the inner face of the light guide when the light passes therethrough. The light reflected at various angles is superimposed at the light emitting face of the light guide to uniform the illuminance of the light. That is, when the light is emitted from the illumination unit, the polarization state is oriented in one direction and the illumination distribution is uniform. In general, a projector is often provided with uniform illumination means, for example, a fly-eye integrator or a rod integrator to uniform the illumination distribution of light from the light source. The illumination unit having the above structure functions as uniform illumination means and polarization conversion means.

[0014] The reflective polarizing plate may comprise a grid polarizer having a plurality of reflective elements arranged in a striped pattern at a pitch that is smaller than the wavelength of incident light.

[0015] In this structure, the reflective polarizing plate can be composed of an inorganic material, therefore having high light resistance and high heat resistance. Thus, this lighting system is particularly suitable for a projector that emits high-brightness light.

[0016] A projector according to a first aspect of the present invention comprises the above-described lighting system, wherein the lighting system is a planar lighting system including a plurality of the light sources that

are arranged in a flat or curved plane and that emit color light beams of different colors in order of time, and the projector further comprises light modulation means comprising a light valve that are driven in a time division mode in synchronization with emerging timings of the color light beams emerging from the light source in order of time, and projecting means that projects the light modulated by the light modulation means.

[0017] In this structure, the lighting system of the present invention contributes to achievement of the compact, thin, and lightweight projector, and improves the efficiency for light utilization, resulting in higher brightness and lower electric power consumption. Furthermore, this projector employs a driving mode called a "color field sequential system." Thus, this projector requires only one light valve (single-plate structure), unlike conventional three-plates projectors having three liquid crystal light valves for three color light beams. Accordingly, the projector requires only one illumination optical system for optical modulation means. Furthermore, the projector requires no color separation optical system and no color combining system, resulting in a significantly reduced number of the components, a simplified structure, and reduced cost.

[0018] A projector according to a second aspect of the present invention comprises a plurality of the above-described lighting systems, wherein each of the lighting systems is a planar lighting system including a plurality of the light sources that are arranged in a flat plane and the lighting systems emit color light beams of different colors: the projector further comprises a plurality of light modulation means comprising light valves that modulate the color light beams emerging from the lighting systems via the polarization conversion means; color combining means that combines the modulated color light beams from the plurality of light modulation means; and projecting means that projects the light combined by the color combining means.

[0019] Also, according to the projector of this structure, the lighting systems of the present invention contributes to achievement of the compact, thin, and lightweight projector, and improves the efficiency for light utilization, resulting in higher brightness and lower electric power consumption. This projector requires a plurality of light valves, unlike the projector according to the first aspect. Since this projector emits different color light beams from the plurality of light sources and has the light valves for these color light beams, it does not require color separation means, which is essential for any conventional display. As a result, it has a simplified structure compared with the conventional structure. Furthermore, synchronization of driving of the light sources with the light valves is not required, unlike the first aspect; hence, the drive mechanism is simplified, and liquid crystal light valves having a lower response rate may be used.

[0020] Embodiments of the present invention will now be described by way of further example only and with

reference to the accompanying drawings, in which:-

Fig. 1 is an outline schematic view of a projector according to a first embodiment of the present invention.

Fig. 2 is a cross-sectional view of one LED of a lighting system in the projector according to the first embodiment of the present invention.

Fig. 3 is a cross-sectional view of another embodiment of the LED according to the present invention.

Fig. 4 is a cross-sectional view of another embodiment of the LED according to the present invention.

Fig. 5 is a perspective view of an embodiment of a reflective polarizing plate used in a lighting system.

Fig. 6 is an outline schematic view of a projector according to a second embodiment of the present invention.

[First Embodiment]

[0021] A first embodiment of the present invention will now be described with reference to Figs. 1 to 5.

[0022] This embodiment describes a liquid crystal projector of a color field sequential system. Fig. 1 is an outline schematic view of an overall configuration of the projector 1 that includes an LED array (light source) 2, retardation films 3, a taper rod lens array 4, a rod lens array 7, a reflective polarizing plate 8, a liquid crystal light valve 5 as light modulation means, and a projection lens 6.

[0023] As shown in Fig. 1, the projector 1 of this embodiment includes the LED array 2 that has a plurality of light-emitting diodes (LEDs) 14R, 14G, and 14B emitting R light, G light, and B light, respectively, (only four LEDs are depicted for simplicity in the drawing); the retardation films 3 provided at the light emitting side of the LED array 2; the taper rod lens array 4 and the rod lens array 7 that uniform illumination intensities of color light emerging from the LEDs 14R, 14G, and 14B; the reflective polarizing plate 8 that converts the polarization of the light from the rod lens array 7; the liquid crystal light valve 5 that modulates each color light from the reflective polarizing plate 8 to form an image; and the projection lens 6 that enlarges and projects the image formed by the liquid crystal light valve 5 onto a screen 9. A lighting system according to this embodiment is composed of the LED array 2, the retardation films 3, the taper rod lens array 4, the rod lens array 7, and the reflective polarizing plate 8. Fig. 2 shows only one LED of the lighting system of this embodiment.

[0024] The LED array 2 is connected to a light source drive circuit 10 that controls timing of the light emission of these LEDs 14R, 14G, and 14B so that the LEDs 14R, 14G, or 14B sequentially emit different colors in order of time, for example, R, G, B, R, G, B, ... In Fig. 2, the right faces of the LEDs 14R, 14G, and 14B are light emitting faces, the LEDs 14R, 14G, and 14B emitting light toward the right. At the rear side (the left in Fig. 2) of the

LEDs 14R, 14G, and 14B relative to the light emitting direction, a curved reflective plate 15 of a metal film is disposed such that a reflective face is directed to the LEDs 14R, 14G, and 14B.

[0025] The taper rod lens array 4 includes a plurality of taper rod lenses 16 of wedge glass columns that are attached to the LEDs 14R, 14G, and 14B with retardation films 3 therebetween. In Fig. 2, the left face of each taper rod lens 16 is a light incident face and the right face is a light emitting face. Each taper rod lens 16 has a taper that diverges outwardly from the light incident face to the light emitting face. Similarly, the rod lens array 7 disposed at the light emitting face of the taper rod lens array 4 includes a plurality of rod lenses 17 of straight glass columns that correspond to the LEDs 14R, 14G, and 14B (taper rod lenses 16).

[0026] The retardation films 3 enhance conversion of the polarization state of the light that reciprocally travels between the reflective polarizing plate 8 and the reflective plate 15. The retardation films 3 impart a phase difference to the transmitted light to enhance the polarization state of the light in comparison with a case having no retardation film. Thus, these retardation films 3 are not limited to ones having a specific phase difference, for example, half-wave or quarter-wave retardation films. Preferably, the retardation films 3 have a nonuniform phase difference, that is, various phase differences at positions transmitting the light, rather than a uniform phase difference such as a half-wave or quarter-wave phase difference. The light reciprocally traveling between the reflective plate 15 and the reflective polarizing plate 8 is subjected to different types of phase modulation in the forward path and the backward path, resulting in an enhanced change in the polarization state.

[0027] The reflective polarizing plate 8 transmits one of the p-polarized light and the s-polarized light (linearly polarized light) of the randomly polarized light emerging from the LED array 2 and reflects the other. Thus, the reflective polarizing plate 8 always emits light having the same polarization direction. The reflective polarizing plate 8 may be a multilayer polarization plate or a reflective polarizer being an inorganic grid polarizer.

[0028] As an example of latter, Fig. 5 shows a grid polarizer, in which many metal ribs 24 (light reflectors) composed of aluminum or the like are formed on a glass substrate 25 at a pitch that is smaller than the wavelength of the incident light. Specifically, the reflective polarizer 8 includes aluminum ribs 24 and air layers that are alternately arranged in a striped pattern and have different diffractive indices at a pitch smaller than the wavelength of the incident light, so that the intensities of the transmitted light and the reflected light exhibit different behaviors depending on the polarization state. When randomly polarized light is incident on the surface provided with the aluminum ribs 24, the s-polarized light vibrating in a direction parallel to the aluminum ribs 24 is reflected while the p-polarized light vibrating in a direction perpendicular to the aluminum ribs 24 is trans-

mitted.

[0029] In the lighting system of this embodiment, the light emerging from each of the LEDs 14R, 14G, and 14B has an luminance distribution with a high luminance in the center and a low luminance at the periphery of the LED. The taper rod lenses 16 and the rod lenses 17 are provided at the light emitting faces of the LEDs 14R, 14G, and 14B in this embodiment. The incident light from the LEDs 14R, 14G, and 14B are repeatedly reflected by the inner faces of these lenses 16 and 17 to uniform the illuminance of the light that is emitted from the light emitting faces of the rod lenses 17.

[0030] When the randomly polarized light having uniform illuminance is incident on the reflective polarizing plate 8, for example, the p-polarized light passes through the reflective polarizing plate 8, while the s-polarized light is reflected by the reflective polarizing plate 8 toward the LEDs 14R, 14G, and 14B. The light reflected toward the LEDs 14R, 14G, and 14B is re-reflected by the reflective plate 15 toward the reflective polarizing plate 8. The reflected light which did not pass the reflective polarizing plate 8 reciprocally travels between the reflective polarizing plate 8 and the reflective plate 15 as long as the polarization state does not vary. In fact, the polarization state of the reflected light gradually varies during the repeated reflection. According to this embodiment in addition to such a spontaneous change in the polarization state, the retardation films 3 provided in the optical paths between the reflective polarizing plate 8 and the reflective plate 15 actively change the polarization state of the light passing through the retardation films 3, enhancing the change in the polarization state. Thus, part of the light reflected by the reflective polarizing plate 8 and reciprocally traveling between the reflective polarizing plate 8 and the reflective plate 15 can pass through the reflective polarizing plate 8.

[0031] The liquid crystal light valve 5 includes a TN-mode active matrix transmissive liquid crystal cell 31 having thin film transistors (TFTs) functioning as pixel-switching elements. The liquid crystal cell 31 is provided with an incident polarizing plate 32 and an emitting polarizing plate 33 on the both faces, the transmission axes thereof being perpendicular to each other. For example, in an OFF state, the p-polarized light incident on the liquid crystal light valve 5 is converted into the s-polarized light and is emitted, whereas in an ON state, the light is blocked. The components of the lighting system, i.e., the LED array 2, the retardation films 3, the taper rod lens array 4, the rod lens array 7, the reflective polarizing plate 8, and the liquid crystal light valve 5 may be separately arranged. However, all the components are preferably in close contact with each other for achieving a compact and thin display.

[0032] Referring to Fig. 1, the liquid crystal light valve 5 is connected to a liquid crystal light valve drive circuit 11 that sequentially drives elements of the liquid crystal light valve 5 in order of time in the elements corresponding to the incident color light components. Furthermore,

the projector 1 of this embodiment is provided with a synchronizing signal-generating circuit 12 that generates a synchronizing signal SYNC and inputs the signal SYNC to the light source drive circuit 10 and the liquid crystal light valve drive circuit 11 to synchronize the timing for emitting color light from the LEDs 14R, 14G, and 14B with the timing for driving the respective elements of the liquid crystal light valve 5.

[0033] That is, in the projector 1 of this embodiment, one frame is time-shared so that R, G, and B light components are sequentially emitted from the LEDs 14R, 14G, and 14B in order of time. Furthermore, the timing for emitting the color light components from the LEDs 14R, 14G, and 14B is synchronized with the timing for driving the respective elements of the liquid crystal light valve 5 to drive the elements of the liquid crystal light valve 5 in order of time in response to the color light components emerging from the LEDs 14R, 14G, and 14B and to output image signals corresponding to the color light components from the LEDs 14R, 14G, and 14B. A color image is thereby formed.

[0034] The projector in this embodiment is driven by a driving mode called a "color field sequential system". Thus, this projector requires only one liquid crystal light valve (a single plate structure), unlike conventional three-plate projectors having three (R, G, and B) liquid crystal light valves. Accordingly, the projector requires only one illumination optical system for optical modulation means. Furthermore, the projector requires no color separation optical system and no color combining system, resulting in a significantly reduced number of the components, a simplified structure, and reduced cost.

[0035] In this embodiment, as described above, the lighting system is provided with the reflective polarizing plate 8 at the light emitting side and the reflective plate 15 at the rear side of the LEDs 14R, 14G, and 14B. The light originally reflected by the reflective polarizing plate 8 and repeatedly reflected between the reflective polarizing plate 8 and the reflective plate 15 is gradually polarized in one direction to pass through the reflective polarizing plate 8 toward the liquid crystal light valve 5. Accordingly, the lighting system has a higher efficiency for light utilization than the conventional system.

[0036] The lighting system of this embodiment is provided with the reflective polarizing plate 8 instead of a conventional PBS array as an element having a polarization conversion function. If a commercially available polarization film is used as the reflective polarizing plate 8, a more compact, thinner, and more lightweight display is achieved. If the reflective polarizing plate 8 comprises a birefringent composite, it has superior properties, such as high light resistance and high heat resistance, particularly suitable for the projector. Since the reflective polarizing plate 8 can receive incident light over the entire surface, unlike the PBS array, it is not necessary to converge the light to a specific position. Thus, the polarization conversion optical system requires no lens, resulting in a simplified structure. Since a wavelength

plate, which is essential for the PBS array, is not required, the number of components can be reduced. Accordingly, the lighting system of this embodiment is very compact and has both a uniform illumination function and a polarized conversion function.

[Second Embodiment]

[0037] A second embodiment of the present invention will now be described with reference to Fig. 6.

[0038] This embodiment also shows a liquid crystal projector. While the first embodiment relates to a single-plate type of a color field sequential system, the second embodiment relates to a three-plate type. Fig. 6 is an enlarged schematic view of a projector. In Fig. 6, components having the same functions as in Fig. 1 are referred to with the same reference numerals, and a detailed description thereof has been omitted.

[0039] In the first embodiment, the LED array 2 having the LEDs 14R, 14G, and 14B that are arrayed in the same plane and emit R, G, and B different colors is used as a light source. In contrast, the liquid crystal projector 36 of this embodiment includes three planar light sources, i.e., an LED array 2R having LEDs 14R that are arranged in the same plane and emit red light, an LED array 2G having LEDs 14G that are arranged in the same plane and emit green light, and an LED array 2B having LEDs 14B that are arranged in the same plane and emit blue light. Retardation films 3, a taper rod lens array 4, a rod lens array 7, and a reflective polarizing plate 8 are arranged at the light-emitting face of each of the LED arrays 2R, 2G, and 2B, as in the first embodiment. Accordingly, the projector of the present invention has three lighting systems; for red, green, and blue colors.

[0040] A liquid crystal light valve 5 for modulating the corresponding R, G, or B color is disposed at the light emitting face of the reflective polarizing plate 8 of each color. The three color light beams modulated in the liquid crystal valves 5 are incident on a cross-dichroic prism 25 as color combining means. This prism 25 is composed of four rectangular prisms bonded to each other, a multilayer dielectric film reflecting red light intersecting a multilayer dielectric film reflecting blue light on the inner faces of these prisms. These multilayer dielectric films combine three color light beams Lr, Lg, and Lb to form a color image. The color image of the combined light is enlarged and projected on a screen 9 through a projection lens 6.

[0041] The projector of this embodiment requires three liquid crystal light valves 5, unlike the display of the first embodiment. In the projector of this embodiment, these liquid crystal light valves 5 are provided for three different color light beams emerging from the three lighting systems; hence, this display does not require color separation means, which is essential for any conventional display. Accordingly, the display of this embodiment has a simplified structure compared with con-

ventional displays. In this embodiment, synchronization of driving of the LED arrays 2r, 2g, and 2b with driving of the respective liquid crystal light valves 5 is not required, unlike the first embodiment; hence, the drive mechanism is simplified, and liquid crystal light valves having a lower response rate may be used.

[0042] Also in this embodiment, the reflective polarizing plate 8 is provided at the light emitting side of the lighting system and reflective plates 15 are provided at the rear of the LEDs 14R, 14G, and 14B. Thus, this display has the same advantages as those in the first embodiment, i.e. a high efficiency for light utilization, a simple structure of the polarization conversion optical system due to nonuse of a converging lens, and a reduced number of components due to nonuse of a wavelength plate.

[0043] The technical scope of the present invention is not limited to the above embodiments, and may include various modifications within the scope of the present invention. For example, in the above embodiments, as shown in Fig. 2, the retardation film 3, the taper rod lens 16, the rod lens 17, and the reflective polarizing plate 8 are sequentially disposed at the light emitting side of each of the LEDs 14R, 14G, and 14B. Alternatively, as shown in Fig. 3, the rod lens 17 may be omitted from the structure shown in Fig. 2. The thickness of the lighting system is thereby reduced. Furthermore, as shown in Fig. 4, the taper rod lens 16 may also be removed; the reflective polarizing plate 8 is directly attached to the retardation film 3 at the light emitting face of each of the LEDs 14R, 14G, and 14B. As a result, the thickness of the lighting system can be significantly reduced.

[0044] In the above embodiments, the number of the LEDs 14R, 14G, and 14B is equal to the number of the taper rod lenses 16 and the number of the rod lenses 17. Alternatively, one rod lens may be provided for a plurality of LEDs. Instead of the array of the LEDs 14R, 14G, and 14B, the light source may be one LED that can emit light with a sufficient intensity. Furthermore, the lighting system of the present invention may be applicable to a direct view display, in addition to the projector shown in the above embodiments.

[0045] As described above, according to the present invention, the polarization state of the light that is reflected by the reflective polarizing plate is changed in one direction and will pass through the reflective polarizing plate toward the light modulation means such as a light valve. Thus, the lighting system of the present invention has a higher efficiency for light utilization than that of conventional displays. Furthermore, the reflective polarizing plate is used in place of a conventional PBS array as a polarization conversion element, in the present invention. The reflective polarizing plate, which contributes to reductions in size, thickness, and weight of the display, is suitably used in a projector.

Claims

1. A lighting system comprising at least one light source, polarization conversion means that polarizes light from the light source in one direction, and at least one reflection plate that is disposed at the rear side of the light source in the light emitting direction such that the reflective face of the reflection plate is opposite to the light source,
wherein the polarization conversion means is provided at the light emitting side of the light source, the polarization conversion means having a reflective polarizing plate that transmits polarized light having a predetermined vibration direction and reflects polarized light having vibration directions other than the predetermined vibration direction.
2. The lighting system according to claim 1, further comprising a retardation film between the light source and the reflective polarizing plate.
3. The lighting system according to claim 2, wherein the retardation film has a nonuniform phase difference.
4. The lighting system according to any one of claims 1 to 3, further comprising a rod or tubular light guide between the light source and the reflective polarizing plate, the tubular light guide having a reflective inner face.
5. The lighting system according to any one of claims 1 to 4, wherein the reflective polarizing plate comprises a grid polarizer having a plurality of reflective elements arranged in a striped pattern at a pitch that is smaller than the wavelength of incident light.
6. A projector comprising the lighting system according to any one of claims 1 to 5,
wherein the lighting system is a planar lighting system including a plurality of the light sources that are arranged in a flat or curved plane and that emit color light beams of different colors in order of time,
wherein the projector further comprises light modulation means comprising a light valve that is driven in a time division mode in synchronization with emerging timings of the color light beams emerging from the light source in order of time, and projecting means that projects the light modulated by the light modulation means.
7. A projector comprising a plurality of the lighting systems according to any one of claims 1 to 5,
wherein each of the lighting systems is a planar lighting system including a plurality of the light sources that are arranged in a flat plane and the lighting systems emit color light beams of different colors,

wherein the projector further comprises a plurality of light modulation means comprising light valves that modulate the color light beams emerging from the lighting systems via the polarization conversion means; color combining means that combines the modulated color light from the plurality of light modulation means; and projecting means that projects the light combined by the color combining means.

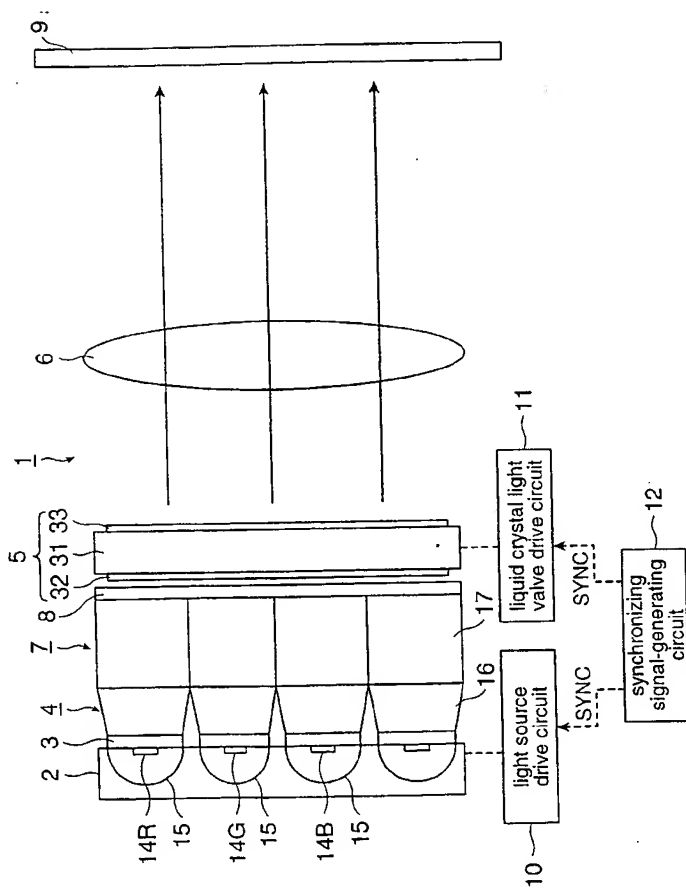


FIG. 1

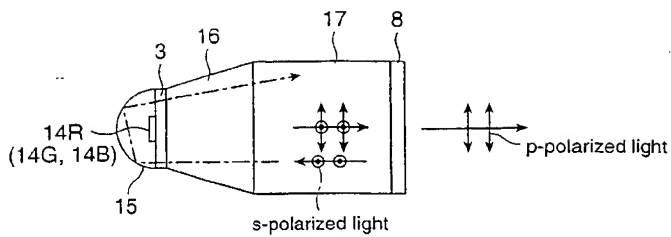


FIG. 2

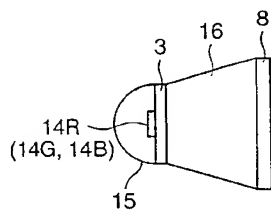


FIG. 3

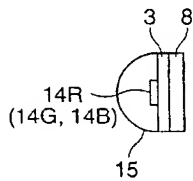


FIG. 4

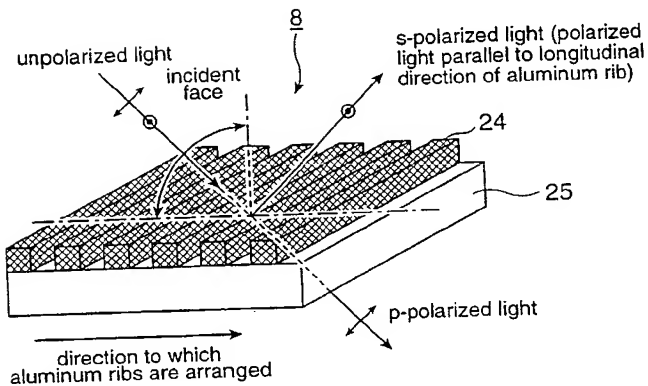


FIG. 5

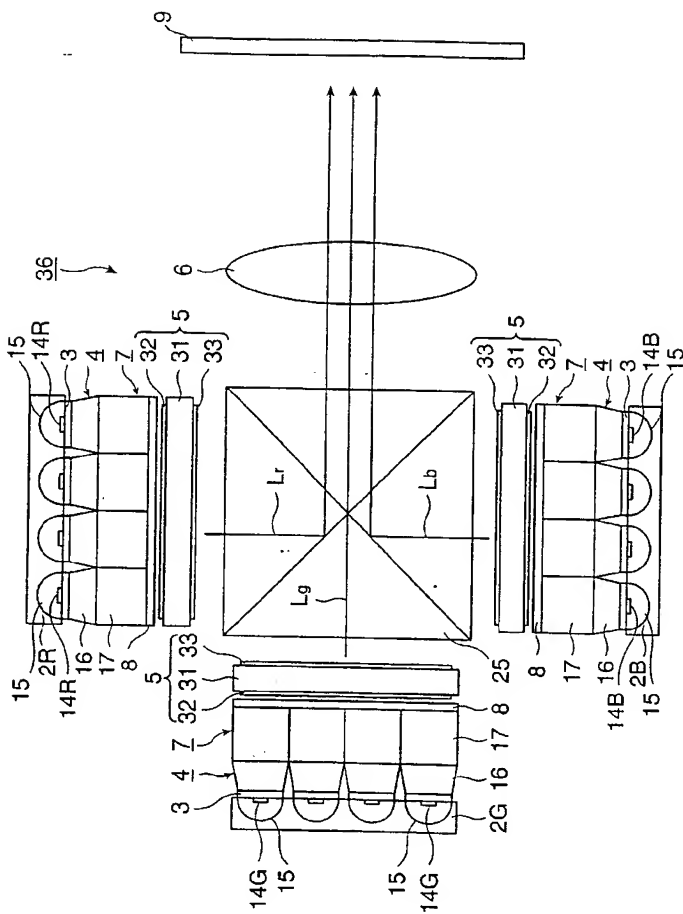


FIG. 6

This Page Blank (uspto)



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11) EP 1 363 460 A3

(12) EUROPEAN PATENT APPLICATION

(88) Date of publication A3:
09.03.2005 Bulletin 2005/10

(51) Int Cl.7: H04N 9/31, H04N 5/74,
G02B 27/28

(43) Date of publication A2:
19.11.2003 Bulletin 2003/47

(21) Application number: 03252873.9

(22) Date of filing: 08.05.2003

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HU IE IT LI LU MC NL PT RO SE SI SK TR
Designated Extension States:
AL LT LV MK

(72) Inventors:
• Sakata, Hidefumi, c/o Seiko Epson Corporation
Suwa-shi, Nagano-ken 392-8502 (JP)
• Takeda, Takashi, c/o Seiko Epson Corporation
Suwa-shi, Nagano-ken 392-8502 (JP)

(30) Priority: 10.05.2002 JP 2002135641

(74) Representative: Sturt, Clifford Mark et al
Miller Sturt Kenyon
9 John Street
London WC1N 2ES (GB)

(71) Applicant: SEIKO EPSON CORPORATION
Shinjuku-ku, Tokyo 163-0811 (JP)

(54) Lighting system and projector

(57) The invention seeks to provide a compact, thin, and lightweight lighting system and projector. A lighting system included in a projector 1 according to the present invention is provided with an LED array 2 having LEDs 14R, 14G, and 14B and a reflective plate 15 at the rear side of the LEDs in the light emitting direction, retardation films 3, a taper rod lens array 4, a rod lens array 7, and a reflective polarizing plate 8.

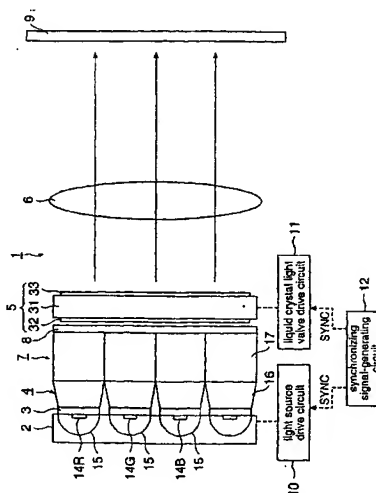


FIG. 1



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 03 25 2873

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	US 6 064 523 A (BUDD RUSSELL ALAN ET AL) 16 May 2000 (2000-05-16)	1-3	H04N9/31 H04N5/74 G02B27/28
Y	* column 5, line 44 - column 7, line 26 *	4,6,7	
X	US 6 108 131 A (GUNTHER JOHN ET AL) 22 August 2000 (2000-08-22)	1,2,5	
Y	* column 21, line 48 - column 22, line 27 *	4,6,7	
A	EP 1 003 064 A (SEIKO EPSON CORP) 24 May 2000 (2000-05-24)	1	
Y	* paragraph [0061] * * paragraphs [0090] - [0095] *	4,6,7	
X	EP 1 200 874 A (MOXTEK) 2 May 2002 (2002-05-02)	1,5	
X	* page 23, line 34 - page 25, line 27 *	1	
	EP 0 837 351 A (COMPAQ COMPUTER CORP) 22 April 1998 (1998-04-22)		
	* abstract; compound 1 *		
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			H04N G02B
1	Place of search		Date of completion of the search
	The Hague		13 January 2005
		Examiner Pigniez, T	
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 03 25 2873

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information

13-01-2005

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 6064523	A	16-05-2000	NONE	
US 6108131	A	22-08-2000	AU 3980699 A	29-11-1999
			CN 1306626 T	01-08-2001
			EP 1078286 A1	28-02-2001
			JP 2002514778 T	21-05-2002
			NO 20005735 A	02-01-2001
			US 2002101659 A1	01-08-2002
			WO 9959005 A1	18-11-1999
			US 6452724 B1	17-09-2002
EP 1003064	A	24-05-2000	JP 3585097 B2	04-11-2004
			JP 2000112031 A	21-04-2000
			EP 1003064 A1	24-05-2000
			US 6547400 B1	15-04-2003
			WO 9963396 A1	09-12-1999
			JP 2004110062 A	08-04-2004
			US 2003147055 A1	07-08-2003
EP 1200874	A	02-05-2002	US 6234634 B1	22-05-2001
			AU 767996 B2	27-11-2003
			AU 6501300 A	19-02-2001
			BR 0012784 A	30-04-2002
			CA 2380435 A1	08-02-2001
			EP 1200874 A1	02-05-2002
			JP 2003506746 T	18-02-2003
			NO 20020398 A	28-02-2002
			CN 1371486 T	25-09-2002
			TW 517172 B	11-01-2003
			WO 0109677 A1	08-02-2001
			US 2003071973 A1	17-04-2003
			US 2002015135 A1	07-02-2002
EP 0837351	A	22-04-1998	US 2001012092 A1	09-08-2001
			EP 0837351 A2	22-04-1998
			JP 10232371 A	02-09-1998
			US 2002159034 A1	31-10-2002
			US 5833360 A	10-11-1998

This Page Blank (uspto)